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Complex systems and economic development

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Abstract
This paper is based on an application of complex systems' approach to economics with the objective of explaining the micro, meso and macroeconomic mechanisms of development. The complex systems' approach makes it possible to tackle the problem of evolution and economic development under conditions of temporal irreversibility, non-linear change and radical uncertainty. This study emphasizes the importance of the relationship between the absorption and connectivity capacities and processes of structural change, creative destruction and appropriation. It shows that capacities and processes interact according to two complex systems' properties: self-organization and adaptation, which account for economic development. In addition, the paper presents some policy issues that derived from the analytical approach of complex systems.

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Introdution

The overall objective of this study is to analyze the phenomena of economic development from a micro, meso and macroeconomic perspective. It uses the approach of complex systems applied to economics (Antonelli, 2007, Foster, 1993, Metacalfe et al, 2006). In this approach, the economic structure can be understood as a set of systems and sub-systems defined at different levels of aggregation. These structures interact

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among themselves within the framework of temporal irreversibility, radical uncertainty, disequilibrium and nonlinear path dependence (Silverberg, Dosi and Orsenigo, 1988; Dosi, 1991; Dosi and Kaniovski, 1994; Antonelli, 2007). This paper considers that economic systems, whether networks, regions or countries, are complex systems whose evolution and change are guided by two fundamental properties, self-organization and adaptation (Foster, 2005). Theses are emerging properties since they are not reducible to the parties' components of the system.

From this perspective, complex systems can be analyzed under the same rules and properties of economic systems at different levels of aggregation. In this approach, economic systems change and evolve according to the aforementioned properties. The property of self-organization drives the system change from its own rules, routines and path-dependence, and the property of adaptation from its interactions with the environment. In this sense, the processes of change and evolution, whether structural change, creative destruction or appropriation process are driven by the said properties and very connected with the agent's capacities. So, economic development is linked with the complexity of a system, as Foster's work (2005) has stressed using the notion of order of complexity[2].

Within this analytical framework, the objective of this work is to discuss the prospects of development of an economic system through the analysis of the interactions between the processes of creative destruction, structural change and appropriation of quasi-rents on the one hand, and absorptive capacity and connectivity on the other, at different levels of aggregation. These processes and capacities that explain the development of an economy are driven by self-organizing and adaptation properties.

This paper takes into account a set of stylized facts derived from a research program in productive networks, innovation and knowledge in Argentina carried out in recent years[3]. Some of the works in the program analyze the skills of actors, their linkages and the relationships among them. In turn, this paper is a reworking of the theoretical framework used in those works which considers the level of skills and linkages of economic agents as the key element for an understanding of generation of knowledge and appropriation of quasi-rent.

These researches have detected a mutual dependence between absorptive capacity and connectivity and have been able to establish the need for minimum thresholds of capabilities to generate linkages that raise the endogenous capabilities. Indicators of absorption and connectivity capacities were estimated for various productive chains such as automotive, steel, wine, fruits, energy, clothing, software and agricultural machinery, among others.

The ideas proposed in this paper on the systems' approach seek to shed light on how complex capacities and processes have feedbacks and evolve over time into a pattern of

[2] The complexity order depends not only on the importance of reaching the adaptation and development of creativity of the actors but also on the presence or absence of mental models and capabilities interconnected.

[3] Some of the works in the program are Novick y Gallart, 1997; Yoguel, Novick and Marín, 2001; Novick et al, 2002; Albornoz, Milesi and Yoguel, 2004; Novick and Yoguel, 2001; Roitter et al 2007, Erbes and Yoguel, 2006; Robert and Silva, 2007; Yoguel, 2007, Silva et al, 2008, Gutman et al, 2008, Albornoz and Robert, 2008.

self-organization and adaptation. In these terms, the paper tries to provide a theoretical contribution to future investigations that integrate capabilities and processes from this analytical perspective.

The rest of the work is structured as follows: The first section introduces the theoretical approach of complex systems and their specificity for the study of different economic structures and economic development issues. The second section provides an analytical model that explains the emergent properties of complex systems –adaptation and self-organization- and order of complexity. This section explains the influence of the level reached by absorption and connectivity capacities on the processes of creative destruction, appropriation and structural change and the subsequent effect of these on capabilities. In turn, it raises the issue of the dynamics of the system and the influence of time in relations between and among these capacities and processes. Given this analytical structure, the third section presents the specificities of developing countries. Finally, the fourth section deals with the main findings and some policy issues.

1. The complex systems and their properties

The approach of complex systems was introduced in economy over the past 20 years by different authors of evolutionist thought. These contributions can be identified from two main perspectives, a stream more associated with the tradition of Schumpetirian thought and a stream that emphasizes mechanisms of adaptations of agents to a particular structure.

The first group of works aims to explain the operation and differential dynamic of production systems (Silverberg, Dosi and Orsenigo, 1988; Dosi, 1991; Foster, 1993; Dosi y Kaniovski, 1994; Dosi and Nelson, 1994; Rizzello, 2003; Witt, 1997; Lazaric and Raybaut, 2005; Foster 2005; Antonelli, 2007). The idea that brings together this patchwork of authors is that complex systems should be applied from the Schumpeterian perspective (1912, 1942) whereby the evolution and economic dynamics of a capitalist system is a process of qualitative change led by innovation with an open end (Fagerberg, 2003).

The present approach to complex systems allows us to understand the morphology and dynamics of economics systems characterized by (i) diversity and heterogeneity of skills and routines of its components, (ii) temporal irreversibility, as a result of a dynamic ruled by a non-ergodic path dependence[4], (iii) disequilibrium interactions among system components, and (iv) the presence of institutional rules, learning, discoveries and space selection operating as coordination mechanisms that allows change and reduce radical uncertainty[5]. As part of this tradition, which incorporates the

[4] This kind of path dependence, when this small shocks at any given time affect the trajectory of long-term in a meaningful way and irreversible (Arthur, 1989), which is Progogine and Stengers (1998) termed chaotic. It occurs when trajectories emerging from points coming away from each other exponentially (nonlinear) over time. Thus, "minor differences, insignificant fluctuations may, if they occur in appropriate circumstances, invade the whole system, engender a new operating system."

[5] This set of positions was clearly illustrated by Silverberg, Dosi and Orsenigo (1988) 20 years ago to argue that: "…in complex interdependent dynamical systems unfolding in historical, i.e. irreversible time, economic agents, who have to make decisions today the correctness of which will only be revealed considerably later, are confronted with irreducible uncertainty and holistic interactions between each other and with aggregate variables. The a priori assumption of an 'equilibrium' solution to this problem to

ideas of Schumpeter and Penrose, most authors argue that the biological metaphor is not the most useful to discuss the specificities of economic systems focusing on complex systems (Foster, 2005; Fagerberg, 2003).

The complex systems' approach takes into account some key elements of economic systems, which conventional economic theory has sidelined by resorting to the notion of equilibrium. Thus, contrary to expectations of conventional economics, the equilibrium of a system is seen, under complex systems' theory, as a situation of disorder and minimal coordination (Mirowski, 1989). This approach differs from the arguments supported by traditional economic theory -which has its foundations in epistemological classical mechanics and Newtonian physics- where the equilibrium is considered a position of command and, hence, requires the existence of perfect connections between system components, namely under the assumptions of perfect information (Foster, 2005)[6].

The second group of authors, including Holland (2004) and others, who are associated with the Santa Fe Institute have focused on the study of complex adaptive systems using the metaphor of biology and advances in artificial intelligence and neural networks. They believe that complex systems are characterized as a dynamic network composed by many actors who have the ability to change and learn from experience. From this perspective, internal models allow players to create skills to anticipate the consequences of their actions and, in the case of the most efficient, be selected by the market (Lara Rivero, 2007). In this regard emphasis is placed on studying the ability of actors to learn and to develop rules of decision in the process of adaptation to the environment, rather than on studying the dynamics of change of a capitalist economy. Hodgson (1993 and 2007) and Lara Rivero (2007) consider that this theoretical stream begins with the work of Nelson and Winter (1982) and represents a break from Schumpeterian thoughts focused on the idea of creative destruction as a key feature of capitalist dynamic.

A common thread between the two groups is characterizing complex systems, taking into account features such as irreversibility, uncertainty, spatial and temporal organization and reproductive capacity. Also, the most significant difference between the two perspectives is that while most of the authors of the first group used the metaphor of disequilibrium thermodynamics and dissipative systems (especially Foster and Metcalfe, among others), the latter used a biological metaphor for the purpose of explaining the phenomena of adaptation and learning.

From the former perspective, the most relevant aspects that explain the evolution of an economic system are not adapting mechanisms to a given structure but generating micro-diversity from innovative processes that change agents' routines that interact in a nonlinear way and under disequilibrium conditions.

Beside the discussions between the two groups, the begining of the idea of self-organization, then resumed by economy, can be found in studies of Prigogine and

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which all agents ex ante can subscribe and which makes their actions consistent and in some sense dynamically stable is a leap of methodological faith."

[6] While the neoclassical economics adopts elements of the physical mechanics for the formalization of their theory, evolutionary and neoshumpeterian approaches take metaphors from both biology and the principles of thermodynamics. The former conceive the idea of equilibrium as a state of order and maximum information and the latter as disorder and entropy.

Stengers (1984). However, the science of complexity, as these authors have called, dates back to the nineteenth century with the birth of thermodynamics and the treatment of the theoretical spread of heat in thermal machines. In its beginnings, thermodynamics introduced the phenomenon of dissipation energy and the concept of entropy linked to Clausius (1865) and to the stream of theoretical physics[7]. Entropy can be viewed as an arrow of time that refers to the irreversibility of qualitative changes because of combustion and the dissipation of energy[8]. The progress of thermodynamics allows us to understand that, contrary to the mechanical changes, which match the ideals of conservation and reversibility, physical-chemical transformations are essentially irreversible (Prigogine y Stengers, 1984). Unlike the dynamic mechanics, according to which the state system and the knowledge of the law governing its development allow a perfect descriptions of both past and future trajectories[9], the thermodynamics of dissipative systems shows that flows crossing certain physical-chemical systems away from the equilibrium can feed phenomena of spontaneous self-organization (Prigogine and Stengers, 1984). Therefore, there are two types of evolution opposed to the reversibility ideal of classical mechanics[10]: one suspended in the past that goes toward equilibrium, and the other, set up by dissipative structures that produce order from hazard. In other words, classical mechanics oppose to the equilibrium and nonlinear disequilibrium thermodynamics. From the latter perspective, associated to dissipative structures, disorder can give life to things, nature and men.

In that sense, in order to establish the property of self-organization in a system, it is necessary to go into non-linear dynamics of feedback that move away from equilibrium, which requires, in turn, an input of energy to counterbalance the entropy naturally generated by the system. Complex systems are dissipative structures that import free energy and export entropy in a way that enables them to self–organize their structural configurations (Foster, 2005). This paper puts forward that a complex system can be conceived as a mechanism for generating order from the absorptive and connectivity capacities of their components. These capacities make it possible to exchange knowledge and energy with the environment, which reduces the losses of entropy. The introduction of these capabilities in the analysis leads to a ranking of orders of complex systems similar to that suggested by Foster (2005). This paper shows a parallel between higher order of complexity and higher degree of development of a productive structure. The complex systems of higher order would required greater absorptive and connectivity capacities, which allow access to the skills generated in the environment in which they operate.

[7]Even Serres (1994) argues that these origins are older because they have their roots in Lucrecio's Tract "De rerum natura" which studies the turbulences and non-.linearity derived from the small deviations in the laminar volume in hydraulics.

[8] As pointed out by the authors aforementioned, heat conversion in movement can only be carried out at the expense of a non-reversible waste and of a useless dissipation of certain quantity of heat.

[9] Whereas in physics, the 'Demon of Laplace' knows all the path dependences available in past, and future derived from initial situations, the Walrasain auctioneer has the role of securing that the transactions take place in conditions of equilibrium, that is to say, without surplus demand in all the markets.

[10] Einstein could even be said to agree with this conception because he understood the irreversibility of the processes as an illusion created by initial improbable situations.

Complex systems' properties

Self-organization and adaptation are two emergent properties of complex systems. The idea of emergency is defined in opposition to methodological reductionism that explains the behavior and evolution of aggregate from the analysis of its components[11]. The complex systems generate hidden variables that are not evident when the parts are studied separately. Therefore, describing a complex system requires understanding not only how the parties function but also how they relate with one another in a non-linear and non- mechanistic perspective.

Property of self-organization refers to the ability of complex systems to create order out of equilibrium through feedback mechanisms (Prigogine and Stengers, 1984). The features of deterministic and non-ergodic path dependence (Antonelli, 2007) explain why the complex systems are sensitive to initial conditions and disturbances occurring along their path, which leads to a diversity of patterns of behavior in the long-term dynamics that affect the overall system (Dosi and Kaniovski, 1994, Antonelli 2007). In this context, property of self-organization allows systems to generate themselves based on their internal structures, namely their routines and path dependence, and the interactions between components. In other words, the economic structure evolves as a result of internal incentives. This property may acquire static or dynamic characteristics depending on whether the objective is to replicate the existing routines or generate another one entirely new.

By adaptation capacity of complex systems we mean the ability to conduct frequent reconfigurations to meet the changes that are generated in the atmosphere. Thus, property of adaptation produces changes that, *a priori*, are a response to external incentives. The more developed the property, the greater are the chances of obtaining benefits from changes in the background, without adversely affecting the trail developed by the system[12]. This property explains why a system can sustain a range of variability in its performance and is able to survive.

The properties of self-organization and adaptation make up a complex system but its order of complexity depends on the level of absorption and connectivity capacities and the dynamic interaction between them. These properties are very important because they constitute a nexus and can be used to explain how the skills lead to change processes that occur at the micro, meso and macro levels.

These properties are the result of different types of interactions generated within a specific pattern that is defined in terms of the evolutionary history of the system. Therefore, there is no deterministic path dependence because complex systems can present deviations caused by random transient shocks (Arthur, 1989 and 1988; Antonelli, 2007; Metcalfe et al, 2006). In this context, it can be argued that these concepts help explain economic coordination without necessarily resorting to the

[11] Reductionism becomes methodological individualism in neoclassical economy because an explanation of macroeconomic variables can be deduced from the analysis of the representative agent's behavior.
[12] Something similar happens in biological systems called resilience (Scheffer, Westley, Brock, y Holmgren; 2002).

equilibrium notion, which is central to conventional economics but is also present in authors who are frequently identified with heterodox economic schools of thought[13].

The following sections define these capacities and processes. They will deal with their interactions as well as the impact on economic development

2. Creative destruction, appropriation and structural change processes: interactions with absorption and connectivity capacities

From a Schumpeterian perspective, competition among agents is understood as a **process of creative destruction** that generates variety through innovation but also reduces this variety through selection mechanisms, which depend on market institutions. Thus, innovation is the result of a process of creative destruction (Schumpeter, 1912 and 1942) which transforms the routines of firms and institutions through formal and informal learning and integration of tacit and codified knowledge and which responds to different logics (Erbes et al, 2006).

The creative destruction process determines, among other things, the level of development of an economy even if creative destruction and economic development co-evolve. While the selection mechanisms tend to diminish the micro-diversity, the creative component of creative destruction process helps to increase it. In this sense, they are opposing forces and so interdependent that they can have an impact both on competition and development (Metcalfe et al, 2003).

The initial differences in the skills of actors, developing innovations and selection mechanisms are key factors in the process of creative destruction (Dosi, 1991). As indicated by Metcalfe, Foster and Ramlogan (2006) the creative destruction synthesizes the two pillars of economic growth: the company that generates the innovation process which is therefore responsible for the "creative" component of creative destruction process and the market which leads the selection mechanism and thus explains component destruction. It is important to point out that competition is understood as a space of generating variety and selecting conduct, rather than as an abstract construction of intersection between the functions of supply and demand. In summary, the creative destruction synthesizes generation and resolution of economic diversity, which constitutes the main source of growth.

The agents -through differentiation of their routines- try appropriating quasi-rents and extraordinary profits derived from competitive process. When the processes of creative destruction are important and specialization is based on productive sectors with increasing returns to scale, the prices of goods and services constitute a dependent variable of innovation. As a result, the market, understood as a mechanism for selecting stems from a specific social construction, not exogenously imposed but considered a result of the process of creative destruction.

The process of creative destruction synthesizes a set of observable factors in an economic system. Among them (i) the path dependence of the rate of innovation, which

[13] We are making reference to some scholars that call themselves heterodox but who, from our point of view, are still associated to the idea of general equilibrium. Some of them are authors of the new theories of international commerce and endogenous development.

is considered at different levels of aggregation (firms, sectors or productive networks) (ii) the emergence and disappearance of sector, that involves the rotation of firms associated with the development of innovative advanced processes and (iii) the degree of economic concentration which reflects the different characteristics assumed by the process of creative destruction and the nature, transitory or structural, of quasi-rents. In this sense, the process of creative destruction is closely related to the processes of structural change and appropriation of knowledge and can only be analyzed in relation to them.

The **process of appropriation** is defined as a set of mechanisms and skills that allow players to transform knowledge into quasi-rents. This process depends on the kind of technology and knowledge management in each system and the dynamics of the processes of creative destruction embodied in the form of competition (market share). (Erbes et al, 2006). The process of appropriation explains the interrelationship among differentiation, innovation, creation of dynamic competitive advantages and appropriation of quasi-rents (Norman, 2002).

So far, the process of appropriation refers to a phenomenon circumscribed to the microeconomic level. However, this process is not only conditioned and strongly affected by meso and macro levels, but can also be defined at these levels. Issues such as club goods (Antonelli, 1997; Erbes et al, 2006), productive networks (Yoguel 2007), technological developments and collaborative innovation clubs (Antonelli, 1997) and territorial level of competitiveness (Granovetter, 1995), among others, show the meso determination of appropriation. Moreover, both the collusive and classical spreading of the benefits of technological progress (Reinert 2007), which is linked with the profile of productive and commercial expertise, gives an account of the macroeconomic dimensions of appropriation.

The different levels of analysis can deconstruct the false dichotomy between appropriation and diffusion, which is often associated with the confusion between information and knowledge and a conception of technology as a public good. At the micro level, the appropriation process can be described as the inverse relationship between appropriation and diffusion (Erbes et al, 2006) and greater appropriation is associated with quasi-rents rising. Nevertheless, at higher levels of aggregation (productive networks, systems, regions or countries) the tension between diffusion and appropriation is lower. In these cases the presence of goods club, productive networks, and local systems of innovation allow higher levels of appropriation without sacrificing dissemination of knowledge. These situations depend mainly on the importance attained by the networks and interconnections within the existing production system, that, as noted above, depend on absorptive capacity but fundamentally on connectivity one. Thus, in a system where networks have a high level of virtuosity, misappropriation and diffusion will be significantly higher given the existence of a high diffusion of knowledge in its interior in the form of club goods, public goods and collusive way of dissemination of the benefits of technological progress. By contrast, in systems with lower levels of complexity, such as those prevailing in less developed countries, appropriation is detrimental to the dissemination which is consistent with the profiles of expertise of these economies. In this sense, economic development is conditioned by the capacity of the system to appropriate knowledge. This together with high circulation and diffusion of knowledge in clusters and production networks raise the level of the appropriation process in an economy.

As a result, the appropriation of knowledge should not be considered an individual process, since the innovation process itself is not. The discussion of the role of knowledge in the development of dynamic and competitive advantages in the appropriation of quasi-rents emphasizes the importance of new organizational forms as network under which economic activity is increasingly organized. New institutional forms respond to the passage from innovative Schumpeterian entrepreneur, to the great Chandlerian organization, and to the production networks that generate change and innovation through learning generated in their linkages and interconnections (Langlois, 2003).

The high number of factors determining the appropriation process prevents this phenomenon from being observed through a single variable. A set of variables and indicators realize the appropriation process. These include the traditional institutional forms contained in intellectual property rights (patents, copy rights, industrial designs, etc.) but also complementary and alternative forms of ownership such as industrial secrets, higher speed in the rate of innovation, control network distribution, technological restrictions to copying and imitation, and so on. To these we can add forms that demonstrate the relevance of networks and the presence of club goods such as books and epistemic communities and codes-displaced books (Cowan, David and Foray, 2000), among others. Theses series of instruments of appropriation are incomplete and are constantly evolving. There are strong sectoral specificities in the process of appropriation and therefore the technological regime (Malerba and Orsenigo, 2000, Pavitt, 1984) and the profile of specialization (Reinert 2007) profoundly affect the internal logic of this process.

Finally, the **process of structural change** is defined as "the system's ability to innovate, to generate complementarities and to reduce structural dualism" (Ocampo, 2005). This concept incorporates both the contributions made by authors such as Prebisch and Hirshman, among others, in the context of theories of development of the 50s, and those generated by new heterodox development (Ocampo, 2005; Ross, 2005; Palma, 2005; Reinert 2007, among others). In addition, this idea includes (i) the reallocation of production factors to high productivity sectors with the aim of reducing the structural dualism and arising the gains from increasing returns, all of which raise overall productivity, (ii) the development of complementarities between the agents, (iii) the generation of changes in the pattern of external integration, orienting towards differentiated products with a higher income elasticity, and (iv) the development of policies to promote coordination of investment decisions in indivisibility of technological contexts (Cimoli et al, 2005). Therefore, the process of structural change is not spontaneous. It is the result of a development strategy which means that players can define their behavior in a game where there are problems of coordination and information complex and in which Paretian equilibrium is not easily achievable (Cimoli et al, 2005).

The process of structural change can be observed from the changes in the production structure at the aggregate level by means of tools such as indexes of similarity of structures and changes in revealed comparative advantages index, among others (Cimoli et al 2005). However, structural change is also evident in processes of more subtle and more profound significance such as reducing the structural dualism and the development of complementarities between firms both at micro and meso levels

(Ocampo, 2006). The analysis of the productivity gaps between sectors at country level and intra sectors at the international level and its evolution over time could account for these variables.

While each of these processes can be understood at the macro, meso and micro-level of analysis, they are manifested with varying intensity in each of them. Thus, the process of appropriation takes place especially in individual agents or productive networks because the generation of quasi-rents derived of knowledge is produced at that level of aggregation. The process of creative destruction takes place at the meso level (Foster, 2005), but with a strong impact on the operation of micro and macro levels. This is because this process is strongly associated with the interaction between actors, which by their nature, transcends the boundaries of the organization. Finally, the process of structural change takes place at a more aggregated level associated with the reallocation of factors among productive sectors, with effects on meso and micro levels.

These three processes then explain the dynamics of change and evolution which, in complex economic systems, is governed by the properties of self-organization and adaptation. In turn, the degree of development of these processes that jointly explain economic development is conditioned by the level reached by absorption and connectivity capacities. Therefore, capacity building, mediated by the properties of self-organization and adaptation of complex systems, determines the degree of development of the processes of appropriation, creative destruction and structural change which in turn, could be considered the determinants of economic development.

The absorptive capacity of the system can be regarded as "the ability to recognize new external information, assimilate and apply it" (Cohen and Levinthal, 1989). This capacity is not related only to the possibility of accessing the existing knowledge in the environment, but also implies the ability to identify useful knowledge and generate new one. As a result, the absorption is not an ability that can be automatically developed nor is equally accessible to all systems, but requires the development of skills within the previous evolutionary path of the system. In this sense, it can be assimilated to the ideas of routines (Nelson and Winter, 1982), dynamic capabilities (Teece and Pisano, 1994) and endogenous skills (Roitter et al, 2007).

This capacity is observable in both individual agents and productive networks. Absorptive capacity can be explained in terms of the organization of work and learning processes, the quality management and the extent of embodied and disembody innovation activities, among other variables.

The capacity of connectivity is associated with the potential of the system to establish relationships and generate interactions with other systems with the objective of increasing their knowledge base. Therefore, different levels of development of this capacity set out options for access to knowledge, resources and opportunities (Norman, 2002; Cullen, 2000; Grandori and Soda, 1995). As with absorptive capacity, the ability to go beyond mere connectivity and interaction involves linkages selected and prioritization of relationships that are established with other systems. Ultimately, this ability is what defines the degree of opening or closing of a system at different levels of aggregation.

Different levels reached by the capacity of connectivity in different systems can be identified from a quantification of connections and links of agents at different levels of aggregation. However, the definition of this capacity does not allow us to weigh all of them with equal importance, since only those linkages aimed at increasing the agents´ endogenous capabilities increase the connectivity capacity. In that sense, both goals and agents should be ranked in terms of its ability to generate additional knowledge and increase the initial capacity of absorption.

The absorption and connectivity capacities mutually reinforce. Systems with higher levels of development of their absorptive capacity tend to be more open and sustain a higher density in its relations with other systems. In turn, these are systems that are better able to reap the benefits arising from interactions generated. At the same time, the density of relations and the degree of openness of the system, defined from the capacity of connectivity, help to develop greater capacity of absorption when it is exposed to significant flows of knowledge that the system must learn to select and use to obtain quasi-rents. Despite the existence of bi-directional, it can be argued that absorptive capacity is a necessary condition for the development of connectivity (Erbes, Tacsir and Yoguel, 2008). This result can also be seen from the approach of percolation (Antonelli 1997, David and Foray, 1994), which states that for knowledge to be absorbed by the system minimum thresholds in both the absorption and connectivity capacities are required. Also, a fundamental property of the percolation is that their probability of occurrence is higher in systems with imperfect connectors and high absorption than the opposite. It is necessary to improve the absorptive capacity so that it is more effective rather than targeting only increase connectivity.

The relationship between capacities and processes in complex systems

As mentioned above, the properties of self-organization and adaptation -as general rules governing the dynamics of change in the system- work as intermediaries in the relationship between capacities and processes (see figure 1). In turn, the relationship between capacities and processes is a reciprocal and mutual relationship reinforced over time.

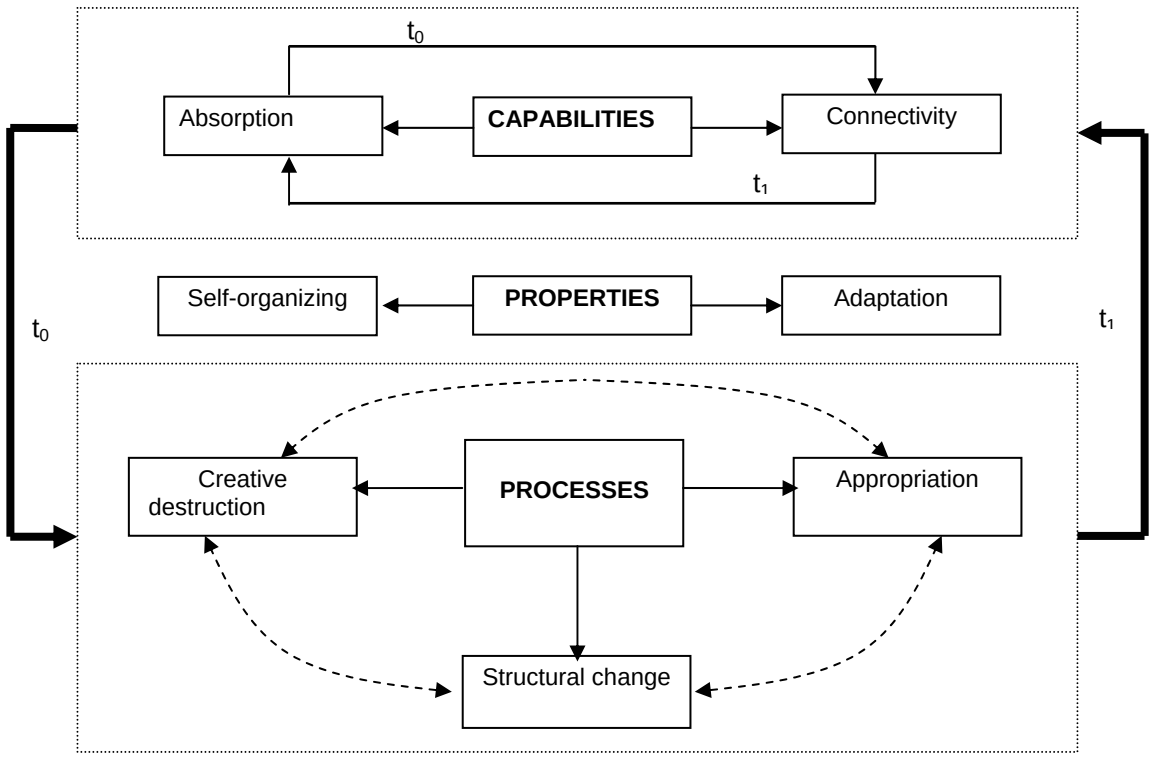
In particular, absorption and connectivity capacities affect the processes through the property of self-organization. Any system, in order to regenerate itself, requires not only knowledge produced internally, but also some knowledge derived from relationships with the environment. Therefore, the dynamic of change that describes the property of self-organization in complex systems requires the existence of linkages with other systems that are functional (connectivity) and skills associated with the identification and implementation of useful knowledge (absorption).

In the presence of minimum thresholds of absorption, the property of adaptation explains the transformation of the system as regards the complexity of the relationships that the agents develop to complement their skills and the generation of innovations in their routines derived from their connectivity capacity. Moreover, the impact of absorptive capacity on the processes can be explained by resorting to the property of absorption which determines the potential of the system to access the knowledge disseminated in networks and environments to which they belong to (Roitter et al, 2007; Erbes and Yoguel. 2007; Borello, Morhorlang and Silva, 2007). Both capacities define the minimum thresholds the agents need in order to appropriate the externalities

generated in the environment and the results of the processes and learning taking place internally. Thus, dissemination of knowledge does not occur randomly among the components of a system, but there is a wide variety of capacities associated to the absorption of knowledge and to the connexion among other agents.

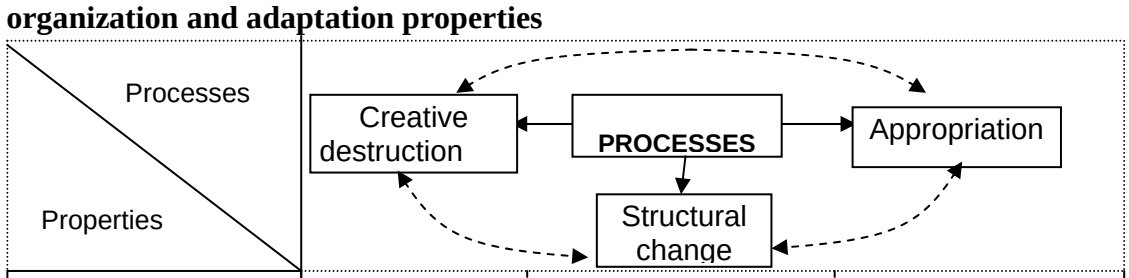
Besides, there are strong interrelationships between the properties of self-organization and adaptation. It can be argued that the property of adaptation of a system is linked to the ability to produce internal spaces that allow agents to regenerate the environment and develop new strategies to survive. In turn, self-organization property is the result of mutations in the system that would not be possible without strong capacities of adaptation.

Figure 1. Complexity of an economic system



When the absorptive and connectivity capacities reach significant levels of development, through the properties of self-organization and adaptation, the system can exploit the conditions given in the environment, including opportunities and risks. In these cases the system can reach an important development in the processes of structural change and creative destruction. However, for this to happen, the presence of channels of communication that allow systems to react to changes (in terms of positive feedbacks) is required. The positive feedbacks let the system absorb elements that enhance endogenous competencies (introducing energy that decreases entropy). On the contrary, the presence of negative feed-backs is reactive to external inputs and damages the self organizational dynamics of the system, increasing its entropy. In such cases, the system's agents resist the changes rather than adapt to them.

Figure 2. Changes in processes necessary to increase the complexity driven by self-organization and adaptation properties



Self organization	To create variety	To generate complementarities	Innovation which raises the new product and process
Adaptation	To improve the selection mechanism	To change de specialization profile according with the technological evolution	To build complex routines in order to reduce the risk of coping and imitation

The properties of a complex system govern the dynamics of change and development of the creative destruction, appropriation and structural change processes, which depend on the capacities mentioned above. The development achieved by all of these three processes depends on the complexity of the system and on the two emergent properties. In terms of **self-organization property,** in order to achieve a high level of complexity it is necessary: to create variety from innovation, to generate complementarities according with the path dependence in order to change the economic structure, and to develop innovation which raises the importance of knowledge intensive products and processes. Meanwhile, in terms of **adaptation property** a high level of complexity is achieved through: the improvement of the selection mechanisms, the change of the specialization profile according with the evolution on techno-productive paradigm and finally, the building of complex routines in order to reduce the risk of copying and imitation (see figure 2).

Summing up, the development of the processes and capacities mentioned above bears a direct and positive relationship with the development of the processes through self-organization and adaptation properties and therefore through the level of complexity of the economic system. The degree of development of the processes highlight -in a second phase- the building of capacities and the complexity of properties that will lead to a development of virtuous dynamics.

3. Creative destruction, structural change and appropriation: the specificities of economic development

In the previous sections we defined the complexity of an economic system related to level and evolution of absorption and connectivity capacities, the processes of creative destruction, appropriation and structural change, and the interactions among them. However, these relationships work in a different way in developing and developed countries[14]. Thus, whereas in the more complex economic systems, the capacities and processes enhance their development path, in the less complex economic systems, capacities and processes act as barriers to improve the development path.

Table 1. Matrix of developed countries

	Micro	Meso	Macro
Structural Change			High incentives to innovate. Embodied and disembodied technical progress. High opportunity. Dynamic competitive advantages derived from interaction (CC). High cumulativeness and appropriation. Generic and specific knowledge base (AC). Increasing returns.
Creative destruction		High barriers to entry derived from endogenous cognitive capabilities (AC). High quasi-rents stability. Epistemic communities (CC). High concentration in the market derived from learning curves (AC). Good and club goods.	

[14] In spite of the fact that we have started from the idea that development is a gradient with some intermediate positions, in this section the analysis is simplified, so development is taken as a binary variable.

Appropriation	⇨	Knowledge generation as a complex processes (AC). Several ways of appropriation: IPR, secrets, displaced code book, high speed innovation (AC, CC). Internal and external sources of learning. They include R&D, patents, production networks, interactions with universities and technological institutions (CC, AC).

Note: Absorption capacity (AC), connectivity capacity (CC).

In developed countries, the higher complexity of economic systems is derived from the higher absorption and connectivity capacities and also from intensity and synergy of the three processes mentioned above (see table 1). In such a framework, the competence's minimal threshold the agents need in order to increase the connectivity capacity is lower because of (i) the presence of externalities (public goods and infrastructure) and (ii) the existence of networks which enable the appropriation processes of club goods generated inside them. As a consequence, processes of creative destruction, appropriation and structural change are generated. In turn, these processes enable greater levels of development, while contributing to reinforce the importance of absorptive and connectivity capacity.

On the contrary, in developing countries, the low levels of capacities act as a limit to appropriation, creative destruction and structural change processes improvement. So, the reduced level of connectivity and absorption capacities has a negative impact on the importance of the processes. As a consequence, the dominant specialization pattern produces low complementarities among agents. In these kinds of countries the competence process is based only on prices and struggles and not on the generation of innovations aimed at increasing variety and improving selection (Table 2).

Table 2. Matrix of developing countries

	Micro	**Meso**	**Macro**
Structural Change		⇨	Mainly industries with static competitive advantages and absence of increasing returns. Generic knowledge base disseminated as a public good (AC). Reduced opportunity. Few interactions (CC). Incorporated technical

		progress (AC). Weak cumulativeness.
Creative destruction	Reduced barriers to entry. Predominance of the destructive aspects of the process of creative destruction (AC). Competition based on price. Weak presence of knowledge networks (CC). Concentration of market resulting from regulations.	
Appropriation	Little or null appropriation of quasi-rents. Great importance of copying and imitation (CA, CA). Internal and idiosyncratic learning sources. Predominance of public and codified knowledge (CC, CA).	

Note: Absorption capacity (AC), connectivity capacity (CC).

Thus, the different ways in which these processes and capacities are manifested define different levels of complexity of economic systems that result in the existence of countries with uneven development potential. In particular, several empirical papers carried out to assess the importance acquired by the absorptive and connectivity capacities reveal that, both during periods of growth and economic stagnation, technological and organizational competencies are weak and are poorly interconnected[15]. At the same time, the connectivity of the agents, both among themselves and with institutions of the national innovation system (NIS), are reduced. These papers show that there is some sort of non-virtuous association between competences and linkages. In such a context reduced levels in both dimensions prevail. Besides, while in developed countries this dynamic partially appears (Tether, 2000; Bidault, Despres and Butler, 1998), a relatively more virtuous behavior associated with the higher importance attained by the absorptive and connectivity capacities prevail.

The importance of structural change processes can be analyzed in terms of characteristics -the kind of technological progress (embodied or disembodied), the relevance of knowledge and the cumulativeness[16]- of main sectors in the productive structure. In developed countries, the structural change process is favoured by the existence of a specialization pattern with high intrasectoral homogeneity. This pattern is

[15] Yoguel, Novick and Marin, 2001; Novick and Yoguel, 2002; Albornoz and Yoguel, 2004; Albornoz, Milesi and Yoguel, 2005; Roitter et al, 2007; Erbes and Yoguel, 2007; Silva et al, 2008.
[16] Cumulativeness refers to the existence of a path of knowledge accumulation in a specific sector.

also characterized by the presence of firms operating in sectors with high barriers to entry[17] that let them appropriate the knowledge generated as quasi-rents. In these cases, decreasing cost prevail (increasing returns to scale) derived from accumulative learning. This kind of learning make possible the presence of externalities and complementarities among agents related to structural change processes (Cimoli, 2005). The strong cumulativeness of knowledge derives also from endogenous efforts in order to build skills making possible the differentiation processes –absorption capacity- and quantity and quality of internal and external linkages produced –connectivity capacity-. In this scheme, the characteristics assumed by cumulativeness lead to the generation of both radical and incremental innovations. Therefore, technological opportunities come from the exploitation of knowledge of complex scientific, endogenous development and interactions with other actors from translation mechanisms (Stokes, 2003).

Developing countries have the opposite traits (see Table 2). These characteristics derives mainly from (i) the predominance of static comparative advantages in the economic structure, (ii), the public character of knowledge and limited cumulativeness, and (iii) the main role of incorporated technological progress through capital goods incorporation. They all limit the generation of structural change processes.

These particular features are manifested by important differences in the specialization pattern. On the one hand, in developed countries the activities that define the specialization profile can be labeled Schumpeterian, since they are characterized by increasing returns to scale, dynamic existence of imperfect competition, technical progress and disembodied innovation efforts and strong synergies among sectors. On the other hand, in developing countries the specialization profile is derived from static comparative advantages, it has the opposite traits and is characterized by the predominance of Malthusian activities (Reinert, 2007).

The differences in specialization patterns are also evident in the complexity of networks generated in developed and developing countries. While in the first case there is a predominance of production networks of knowledge integrated into the national innovation system, in the second one such networks are either virtually non-existent or very weak. Therefore, developing countries are characterized by the presence of linkages among agents that assign less importance to the endogenous knowledge generation. Anyway, this characteristic does not override the possibility that some industries may exist within the prevalent dynamic profile of specialization.

In relation to the appropriation process, it is necessary to consider those aspects that help explain why the knowledge produced by an agent or a set of agents constitutes a barrier to entry and becomes a source of quasi-rents. This issue will depend on the absorption and connectivity capacities related to (i) how to get knowledge from different sources, (ii) the generation of learning, (iii) integration between different types of knowledge (David, Cowan and Foray, 2002; Johnson, Lorenz and Lundvall, 2002, Erbes et al 2006), and (iv) the form of ownership of the quasi-rents generated from knowledge. From this perspective, more complex economic systems develop competencies that can help to reduce the risk of imitation. In these cases, there is a predominance of agents in which learning is generated from multiple internal and external sources arising from R&D, interactions with universities and technology

[17] Both are based both in market regulations and development of cognitive capabilities.

centers, patents, property club and production networks, among others. Some of these -especially the last three- become mechanisms that allow the appropriation of knowledge. In a virtuous extreme, these processes arise the levels of absorptive and connectivity capacities.

From the perspective of appropriation processes, developed countries stand out because of different ways of appropriation: IPR, secrets, displaced code book and high-speed in the innovation rate. In turn, firms' residents in these countries can reduce the costs of R&D and increase the likelihood of successful innovations decentralizing activity in many innovative start-ups, which increase diversity and reduce the costs of R&D multinationals and large enterprises through acquisition processes. This is a consequence of the high absorption and connectivity capacities of system's agents.

In contrast, in developing countries, the learning and technological processes are mainly embodied and are poorly fuelled by knowledge derived from basic and applied science and firms' linkages with environment. Meanwhile, the appropriation process in developing countries is characterized by low or null quasi-rents appropriation and high imitation and copy. These sources are related to low absorption and connectivity capacities which condition also the probability to emulate.

The process of creative destruction also provides important differences between developed and developing countries. This process is aided by the development of certain market structures arising mainly from a prior accumulation of knowledge, technology interrelationships being central. This framework refers to the presence of increasing returns, the magnitude and persistence of barriers to entry and, hence, the ability of actors to generate technological quasi-rents and to appropriate them (Pavitt, 1984; Reinert, 1995).

In more complex economic systems, competitive processes are characterized mainly by the presence of oligopolistic markets. In these cases, high barriers to entry resulting from cognitive abilities growing internal and learning curves prevail. Besides, agents can take advantage of technological interrelationships and complementarities of knowledge arising from the presence of increasing returns to scale. As a consequence, agents have a low mobility and compete among themselves in concentrated markets through radical innovations that are manifested in a combination of accumulation of competencies and creative destruction. As a result, the degree of stability of quasi-rents generated by the integration of knowledge is greater than in those systems where agents compete in free entry markets. Thus, in spite of operating in sectors with strong technical progress and instability, it is possible for them to decode the uncertainties of the environment. This behavior is possible given the presence of a high level of absorptive and connectivity capacities.

On the contrary, in developing countries, weak absorptive and connectivity capacities condition the importance of the processes of creative destruction. The barriers to entry are reduced as a result of the existence of competitive markets near perfect competition regulated primarily via prices. Thus, concentration in markets does not derive from paths of growth and learning as evidenced in developed countries, but they respond to specific regulations that favor certain activities and productive sectors. It also highlights the shortage of knowledge networks belonging to different agents.

The character of structural change, the creative destruction and the appropriation processes, and absorption and connectivity capacities, as their interrelationships, determine all together the degree of complexity of economic systems and the possibilities of economic development.

In particular, with regard to developing countries, several authors show the weaknesses in the work we have identified under the concept of processes. Thus, Reinert (1995) argues that in such countries there are severe constraints affecting the chances of appropriating quasi-rents derived from the knowledge and the sharing of benefits arising from technological progress. With regard to the latter dimension, this author argues that in developing countries, the classic form of distribution of benefits of technological progress dominates. This form derives from: (i) a specialization pattern where diminishing returns are key, (ii) the limited possibilities to implement protection mechanisms defined in a wide way (i.e. beyond IPR and to include forms of collective protection) to avoid imitation and to access to quasi-rents generated inside, and (iii) the dominance of competition based on price. From this perspective, the specialization pattern is a key factor in order to differentiate processes of appropriation of knowledge and competence via creative destruction that affects, at the same time, the path of structural change.

The predominant pattern of productive and service specialization in developing countries is characterized by limited processes of knowledge appropriation, structural change and creative destruction -and even by 'destructive destruction'- (Reinert, 2007) as a consequence of the low development of absorption and connectivity capacities. These patterns are associated to diminishing returns to scale, perfect or close to perfect competition in markets with strong volatility of prices, a demand for unskilled labor and use of low quality processes and technical progress mainly incorporated. This uneven production specialization is reflected in the mechanisms for the appropriation of knowledge closer to traditional forms of protection and with weak spill-over on the productive structure. As a consequence, the possibilities to make the economic system more complex are reduced.

Therefore, the firms' choice of what kinds of goods and services they should be produced or offered defines a set of dimensions related to the importance of acquiring knowledge, the kind of returns, the generation of competitive advantages and market forms which are closely linked to the capacities and processes discussed in this paper[18] (Rosenberg, 1982; Reinert, 1995, 2007; Rodrik, 1999).

4. Conclusions and policy remarks

In the previous sections we have stressed the fact that developing countries face the challenge of building absorption and connectivity capacities and of increasing the importance of quasi-rents appropriation derived from knowledge, and creative destruction and structural change in order to generate a development path. We have also stressed that when the main characteristics of the specialization pattern are the predominance of decreasing returns, the process and capacities are very weak and therefore the possibility of creating a development path and high complexity levels in terms of self-organization and adaptation properties are very low. In these cases, the

[18] Reinert (2007) shows that the Washington Consensus Decalogue is not a sufficient condition to generate a development path when the specialization pattern is not associated to increasing returns.

leaking of knowledge is higher than knowledge appropriation. Competitive processes are not guided by creative destruction but instead are based on (i) prices increase derived from predatory practices which accentuate the destructive component of the creative destruction process (Reinert, 2007) and/or (ii) mainly non incorporated technical change. In consequence, instead of a structural change there is structural heterogeneity, a low level of complementarities and high productivity gaps between sectors. In sum, the weaknesses of the specialization pattern are associated with the low probability of economic development. So, the challenge for developing countries is to make much more complex the specialization pattern in sectors in which the agents are price-formers rather than price-takers, and in which the development of absorption and connective capabilities becomes a key factor in the competition process. Developed countries have absolute advantages in the most technologically dynamic sectors and in most dynamics stages of production chain. This issue requires industrial and technological policies since a free market will consolidate the dominant positions in the world market.

An approximation to competition from the complex systems theory, as it is assumed by this paper, starts from the hypothesis that economic development -conceived as a creative-destruction process, appropriation of quasi-rents and structural change- involves transit through a disequilibrium path in order to get a high level in both absorption and connectivity capacities. In this sense, interventions should go beyond the idea of solving market failures for two reasons: (i) because public policy should not aim at market equilibrium and (ii) because market failures are the rule rather than the exception of the way the market works (Possas, 1987). Because of all this, economic policy should never be a temporary but a permanent intervention in a continuous path of revision and change. As a result, the transit through a development path is only possible with the support of a public policy oriented to (i) the generation of complementarities among agents, (ii) the emergence of new sectors and (iii) the improvement of innovation mechanisms (Castaldi et al. 2004).

The analytical framework based on complex systems theory –and applied to economics- provides also an appropriate framework for the discussion of policies from a systemic perspective. This issue is especially relevant in developing countries where there are high restrictions for the development of knowledge-intensive activities and great limitations for productive complementariness among agents.

In this sense, to meet the objective of increasing the level of capacities and processes, and hence create potential for development, the industrial and technological policy should take into account the issues discussed in this paper.

The design of these policies needs to move along a path in which there is tension between public and club goods. On the one hand, knowledge is increasingly becoming a club good with restricted access derived from the level of development of the absorption and connectivity capacities discussed in the previous sections. On the other hand, in the present knowledge intensive techno-productive paradigm, the chances of development are associated with a wide dissemination of knowledge in the form of public goods as well as club goods because of the growing importance of production networks. This situation does not imply an inability to capture and generate quasi-rents but it entails more openness in the competitive process (greater variety and better selection) where

barriers to entry are generated from agents' different competences on the one hand, and appropriation, creative destruction processes and structural change, on the other.

In the first place, in order to obtain a major virtuosity of appropriation processes, the extent to which public goods are present becomes a key issue since they constitute a basic input for the development of club goods. For this purpose, it is necessary to improve the education system –especially at primary and secondary levels- to avoid the rise of perverse selections mechanisms, and to create equal opportunities to have access to both formal and informal education. Besides, and from the perspective of the determinants of quasi-rents appropriation, policies should focus on a significant increase in cumulativeness knowledge incorporated in the production of goods and services. This entails not only harnessing the company's external sources by improving the inter-phases between the firms and the scientific system but also improving the internal sources consolidating the basic competencies of the agents and the circulation of information and knowledge inside the companies and networks they belong to. This implies the development of institutions that both allows the appropriation as a system of intellectual property rights and reinforces alternative and endogenous forms of protection, such as high innovation rates and high cognitive capabilities, enabling agents to make up epistemic communities in which club goods circulate.

On the other hand, actions oriented to improve the processes of creative destruction should be related to increasing the weight of the knowledge-intensive actors through the selection of sectors with potential for development -which increasingly incorporates knowledge- and the promotion of new ones. This requires the application of a vertical policy that raises the level of knowledge in the present productive structure and modifies the specialization profile by taking advantage of steep learning curves associated to key sectors in the new paradigm. Therefore, the vertical policy must be centered on (i) the promotion of learning processes and competitions among agents; (ii) the generation of dynamic market failures and processes of technological accumulation with positive externalities, and (iii) the incentive to innovate and to create institutional mechanisms to reduce the selection failures. In turn, all these policies entail the development of incentives to build complex routines in order to increase the knowledge protection and allow greater appropriation of quasi-rents coming from barriers and imperfect competition and from development of monopolistic rents from emulation patterns (catching-up).

In turn, the promotion of structural change process requires the development of knowledge and productive complementarities among agents. In both cases the creation and consolidation of organizational structures –such as different kinds of networks- connect the market and firms. These organizational structures have a key role when they promote complementarities among agents, as well as institutions operating as translators and/or organizations bridge (Casalet, 2005). Besides, to make these process more dynamics it is necessary to discuss the specialization pattern, promoting the development of those activities with increasing returns enabling productivity increase that could spill into other activities. In turn, these activities favour a more virtuous export specialization pattern in terms of knowledge embodied in products and services.

In order to develop absorption capacities and to spread knowledge and information inside and among companies and production networks, it is necessary to create incentives for the development of endogenous competencies centered in (i) the systemic

training of workers and employees[19], (ii) the development of processes of continuous improvement and quality assurance (Formento y Braidot, 2007), (iii) post-Taylorist forms of work organization (Delfini, Roitter y Pujol, 2007) and a significant increase in the role of design as a source of generation of quasi-rents (Silva et al, 2008).

The development of connectivity capacities requires linkages of firms with the national and sectoral innovation systems from the perspective of a non- lineal model (Stokes, 1997). On the one hand, the policy should be oriented to get a major position of local agents in the hierarchy of the global network they belong to, which implies developing a public policy that takes into account private relationship nucleus-supplier-client. In this sense, the enhancement of the generation, circulation and appropriation of knowledge in order to create dynamic competitive advantages is necessary. On the other hand, the policy should consider the development of linkages firm-university within the framework beyond the individual supply and demand conceptions and also the training of human resources. This requires the prioritization of basic research oriented to vacancy areas and the development of translations functions among agents in terms of languages and discovery of new contexts. All these actions should be complemented with the infrastructure development of ICT of free access.

The final goal of this kind of policy is moving in the path of development. Therefore, because of the synergy generated by the processes and capacities associated with complex systems, the policy objectives are strongly linked. The improvement of the management of knowledge by integrating tacit and codified not only has a direct impact on the level of agent's absorption capacities but also on the connectivity ones. In other words, policy tools acting both from the demand and supply perspective are necessary. However, this also needs significant changes in the organization of firms into more complex structures in order to include projects in competition in a context of top-down and bottom-up relationships simultaneously. Changes in these directions will enable firms to diversify the sources of learning complementing the incorporation of incorporated technical progress with de-incorporated one such as the development of formal and informal R&D activities, design, integration of knowledge from different areas of the organization using specific software, etc. Therefore, an increasing complexity in firms' knowledge management should produce a greater weight of patents, a greater importance of codificable but un-coded knowledge (displaced code books as Cowan et al stated) and a speed of innovation greater than that in rival firms. Finally, this set of policies associated with each of the processes analyzed will also tend to generate a significant increase in agents' absorptive and connectivity capacities and therefore in the emergence of the two complex systems associated properties: self-organization and adaptation.

The final objective of all these policy actions is to encourage an upgrading of the structural change path. It should focus on inducing a complex profile of specialization in goods and services and on increasing the weight of sectors located in the higher levels of productivity.

This set of tools, which aims to improve the capacities and processes discussed above, should be approached from a dynamic perspective such as Ernst and Lundvall (2004)

[19] This refers to the fact that it is necessary to plan, organize and evaluate methodologically ex-post training processes, given the existence of differential competencies of the agents.

and Evans (1995). This analytical stance is heavily influenced by the specialization pattern and also by the endogenous capabilities available.

Finally, as Reinert (1994, 2007) has proposed, from a neo-Schumpeterian approach, it is possible to identify uneven development in developing countries when: (a) the appropriation process is weak (classical diffusion), (b) the country specialization is focused on economic activities with low rate of innovation and, therefore, (c) the destruction component of creative destruction process predominate over the creative one. In these cases it is easy to specialize in being poor in the international division of labor. If the specialization pattern is focused on products with exogenous innovation processes, the discussion about appropriation does not make any sense. As consequence, the path of growth of this type of countries will strongly depend on international prices of main products in the specialization pattern and not on their absorption and connectivity capacities which, in turn, condition the possibilities of agents to innovate and to appropriate quasi-rents related to knowledge.

From this perspective, appropriation, creative destruction and structural change processes, on the one hand, and absorption and connectivity capacities, on the other, become key points in the development process and structural change path. The development of capacities and processes from a complex system approach applied to economy means taking advantage of windows of opportunity by choosing the right technology and knowledge management and operating in oligopolic markets in order to participate in virtuous global production network. These windows of opportunity are a moving target (Perez, 2004; Reinert, 2006), and they depend on the processes, capacities and properties previously discussed.

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